The features of the specific ore types grinding automated control in the ore preparation process

Anatoly Matsui

Associate professor of the production processes automation department, PhD, Kirovograd National Technical University, Ukraine

Abstract

The research results, which showed that it is advisable to process the specific types of ores considering the features of the technological process conducting and automatic control at concentrating plants, are presented.

Key words: AUTOMATED CONTROL, GRINDING, ORE TYPES, AUTOMATIC LOADING, PULP THINNING

At present in Ukraine, the base iron ore, as well as a significant part of the high grade ores are subjected to beneficiation due to the decrease in their mineral content. The ore preparation involves the ore grinding prior to the disseminated minerals disclosure before beneficiation. The large amount of electricity (about 50% of all costs) and materials is consumed for grinding in Ukraine. This increases the concentrate cost and, as a consequence, the cost of the metal that is becoming uncompetitive on the world market. Therefore, this problem permanently is a component of the most important scientific and practical problems of the country. There were performed a lot of research and publications about these issues, but the strategic direction of problem solution was not identified. Since 1970s ore averaging during the processing was used, much later the selectively processing of the specific ore types of the particular concentrating plants was started. In [1] it is noted that the ore processing is carried out in the averaging mode, or in the accordance with the specific ore types. However, a research report [2] states that the ore averaging systems were not found wide spread. Despite the revolutionary publication [3], basically the attempts of the ore averaging during processing are continuing. Therefore the problem of proving the advisability of separate ores processing, including the issues of automatic process control is relevant, which is the purpose of the present paper.

By the supervision of the drum mills work on a magnetic concentrating plant it is determined that the manual regulation of the ore loading to the

technological aggregate, its actual efficiency is about 60 ... 65% of the maximum possible [4], and this is due to specific reasons. The operation of these automated mills for a long time is provided the increased productivity by 20 - 30% in comparison with manual control [4]. Thus, in solving the problem of the separate ore processing it is necessary to focus on the automated operation of process equipment. The greatest efficiency of the ball mill is possible to get by maintaining the optimal ball loading and balls particle size characteristic, providing technological unit optimal ore loading and maintaining the pulp thinning at a required level in it. The solution of these problems is also complex and the optimal answers are not found yet. The mill balls composition is not known exactly, as well their additional loading instead of worn ones is carried out once a day by the grinding bodies of the maximum size - typically 100 mm. Such balls composition is not optimum. Decrease of the ball loading during the day reduces the performance of the mill during this time by about 1,7%.

Work [5] shows that it is possible to select the required balls composition and their number, which will not change in time. At the same time ball load particle size characteristic may be smoothly varied. For each ore type it is possible to choose the best ball load and optimal pulp thinning and the dependence of pulp thinning change on the crushed ore average particle size by the experiments in the production conditions. Then it becomes known as the pulp thinning indicator in this ore type as well its law of change due to the fluctuations of the initial ore particle size. Today this indicator is unknown, intuitively installed and approximately maintained by the operator, which leads to significant losses. Thus, the separate sections of concentrating plant is possible to customize for processing of specific ore types. Thus, during processing specific ore types it is relatively easy to maintain the desired amount and composition of the ball load, which will be optimal for a given material, as well as to establish the optimum tasks to the ore / water ratio and laws of its change from the solid particle size. The automatic control systems for the mills pulp thinning have already been created [6, 7, 8]. They are based on the developed scanning tools, for the opened surface streams [9], on the improved conveyor scales [10] and on the hydrostatic transducer [11, 12, 13]. For realization of the developed systems it is necessary to identify the ratio of solid/liquid $K_{T/G}$ in the ball mills. For the ball mill, which processes the original ore with the classifier sand the following dependence is obtained [14]

$$K_{T/G} = \frac{A(Q_{VP} - Q_{VG}) + Q_P}{Q_{VM} + Q_{BGM} + K_n[A(Q_{VP} - Q_{VG})]}, \quad (1)$$

where $A = \delta_P / [1 + K_n(\delta_P / \delta_B)]$ - is the constant for a particular technological situation; δ_B, δ_P –is the density of water and ore, respectively; K_n –is the classifier sands humidity; Q_P, Q_{VM}, Q_{BGM} – are the mass flow rates of the ore, mill water, the water to the classifier sand chute, respectively; Q_{VP}, Q_{VG} –are the volumetric flow rates of pulp and water in the classifier sand chute, respectively.

For the ball mill, which processes the double-stranded classifier sands the dependence of the following form [15] is obtained

$$K_{T/G} = \frac{\delta_P(P_H - \delta_B g H_C)}{\delta_B(\delta_P g H_C - P_H)}, \quad (2)$$

where P_H – is the overpressure at the bottom portion of the receiving device of the cochlear feeder; H_C – is the pulp level; g – is the free fall acceleration.

As is seen from (1) and (2) for the identifying of the mill pulp thinning it is also better to work with a specific ore, where its density δ_P is known. Otherwise, the system becomes complicated or the accuracy of its operation decreases.

The mill ore loading is advisable to measure by the energy of the lumpy material destruction [2]. In [16] the mathematical model of a ball mill ore loading is obtained. It has the following form

$$V_P = \frac{E l_T^2}{2 k k_1 k_2^2 l_0 k_T^2 R_T^2}\left(S_2 \Delta R_2^2 - S_1 \Delta R_1^2\right), \quad (3)$$

where V_P – is the crushed ore amount, by which one may evaluate the technological aggregate loading; E – is the Young's modulus of the deformable transducers material; l_T, R_T, k_T – are the base, the resistance and the coefficient of strain-gauge-sensitivity of the secondary transducer, respectively; ΔR_1, ΔR_2 – are the resistance increment of the main and auxiliary transducers, respectively; l_o – is the initial length of primary transducers; S_1, S_2 – are the cross-sectional areas of the primary transducers, respectively; k – is the proportionality coefficient which depends on the strength (type) of ore; k_1 – is the constant, which characterizes the relationship between the total volume and the volume of the deformable piece of ore; k_2 – is the coefficient, which determines the

amount of the primary transducer length occupied by the secondary transducer.

Using (3) it is possible to construct the graphs shown in Figure 1.

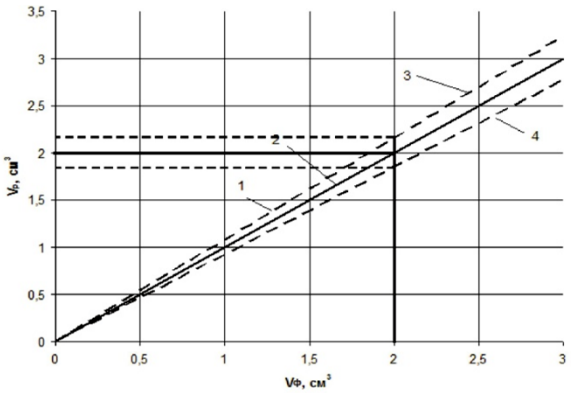

Figure1. The dependence of a certain amount of coarse ore particles at the face of the primary transducer on its actual value in the case: 1 – is the meter setting to the specific ore type; 2, 3, 4 – are the transducer settings on the medium strength ore

From these, it follows that the best identification results may be obtained in the case of processing a specific ore type. Using (3), it is advisable to build an adaptive control system of ball mill loading based on the Rittinger crushing law [17]. The control algorithm includes the ore density, and the indicator characterizing its grindability. It also underlines the usefulness of the separate processing of the ore specific types at the processing plant.The possibility to process the ores specific types is currently possible due to the works [18-22], performed at Kryvyi Rih National University.

Conclusions

The research results show that, it is advisable to process the specific types of ores considering the features of the technological process conducting and automatic control at concentrating plants. This will allow to significantly reduce the cost of the concentrate.

References

1. Bondarenko A.V. (2010). The variant of the development of the automatic systems for pulps analytical control, *Gorniy Zhurnal*, No10, p.p.75-80.
2. Pivnyak G.G., Vaysberg L.A., Kirichenko V.I. et al. *Izmelcheniye. Energetika i tekhnologiya* [Power engineering and tehnology]. Moscow, Ruda i Metally, 2007.
3. Bilenko L.F. (2000). Regularities of co-grinding of mineral components with different strengths, *Obogashchenie Rud*, No1, p.p.7-10.
4. Ganzhenko I.M., Pluzhnov Yu.V., Goncharov S.A. et al. (2008). Automation of ore loading in the first stage of crushing mills in Abagurskom branch of OJSC "Evrazruda", *Obogashchenie Rud*, No4, p.p.39-40.
5. Kondratets V.A, Reva O.M, Karchevska M.O. (2008). The theoretical investigation of sustainable and transient states of balls and lining in mills, *Tekhnika v silskohospodarskomu vyrobnytstvi, haluzeve mashynobuduvannya, avtomatyzatsiya: coll. sci. works KNTU*, No21, p.p. 187-196.
6. Patent 40465 Ukraine, MKV 7 B 03 B 11/00, B 02 C 25/00. *Prystriy avtomatychnoyi stabilizatsiyi rozridzhennya pulpy v mlynakh z tsyrkulyuyuchym navantazhennyam* [The device for the pulp dilution automatical stabilization in the mills with a circulating loading]. Kondratets V.A, Serbul A.M.; patent owner Kirovograd National Technical University. No u200813005; subm. 10.11.08; publ. 10.04.09, Bull. No 7.
7. Kondratets V., Serbul O. (2013). Grounding of computer systems identification and regulation of pulp dilution in the ball mils with circulating load. *Visnuk of Kryvyi Rih National Universuty*, No 34, p.p.45-50.
8. Matsui A.N., Kondratets V.A. (2012). Automatic stabilization of relations ore/water in a ball mills, grinding sand classifier, *Innovative materials and technologies in metallurgy and mechanical engineering*, No2, p.p. 115-119.
9. Kondratets V.A. (2013). Theoretical study of surface scanning of the open material flow with the constant length beams, *Visnuk of the Kryvyi Rih National University*, No35, p.p.175-178.
10. Kondratets V.A. (2014). Measurement of mills ore load with conveyor dual signal filtering linear load weighting, *Electrotechnic and Computer Systems*, No13, p.p. 62-69.
11. Kondratets V.A., Matsui A.N. (2008). The theoretical study of open bottom converter for liquid media parameters, *Tekhnika v silskohospodarskomu vyrobnytstvi, haluzeve mashynobuduvannya,*

avtomatyzatsiya: coll. sci. works KNTU, No21, p.p. 49-54.
12. Kondratets V.A., Matsui A.N. (2012). Theoretical research of the effect of perturbations on the testimony of open bottom hydrostatic converter, *Visnyk of Vinnytsia Politechnical Institute*, No 6, p.p. 21-25.
13. Kondratets V.A., Matsui A.N. Achieving of the partial invariance for the open bottom hydrostatic transducer to the influence of disturbing factors, Proceedings of the XII International Conference [Measurment and control in complex systems (MCCS - 2014)], Vinnytsia, Ukraine, October 14-16, 2014, Vinnytsia: VNTU, 2014, p.p.127.
14. Kondratets V.A., Сербул О.М. (2013). The theoretical study of one spiral classifier sands thinning by the source with a constant water flow rate, *Tekhnika v silskohospodarskomu vyrobnytstvi, haluzeve mashynobuduvannya, avtomatyzatsiya: coll. sci. works KNTU*, No26, p.p.173-180.
15. Kondratets V.A., Matsui A.N. (2009). Identication of ore/water correlation in the process of classifier sands blending, *Visnyk of Vinnytsia Politechnical Institute*, No3, p.p. 8-12.
16. Kondratets V.A., Karchevska M.O. (2011). Identification of the ball mill ore loading according to the parameters of energy efficiency of material destruction, *Visnyk of Vinnytsia Politechnical Institute*, No5, p.p. 9-13.
17. Kondratets V.A., Karchevska M.O. (2011). The theoretical study of the adaptive control of the ball mill ore grinding. *Visnyk of the Kryvyi Rih Technical University*, No28, p.p. 196-200.
18. Morkun V., Morkun N., Pikilnyak A. (2015). The study of volume ultrasonic waves propagation in the gas-containing iron ore pulp, *Ultrasonics*, No 56C, p.p.340-343.
19. Morkun V., Morkun N,. Pikilnyak A. (2014). Ultrasonic facilities for the ground materials characteristics control, *Metallurgical and Mining Industry*, No2, p.p.31-35: http://www.metaljournal.com.ua/assets/Journal/a6.pdf
20. Morkun V., Tron V. (2014). Automation of iron ore raw materials beneficiation with the operational recognition of its varieties in process streams, *Metallurgical and Mining Industry*, No6, p.p. 4-7: http://www.metaljournal.com.ua/ assets/MMI_2014_6/1-MorkunTron.pdf
21. Morkun V., Tron V. (2014). Ore preparation multi-criteria energy-efficient automated control with considering the ecological and economic factors, *Metallurgical and Mining Industry*, No5, p.p. 4-7: http://www.metaljournal.com.ua /assets/Journal/1-MorkunTron.pdf
22. Morkun V., Tron V. (2014). Ecological and economic optimization of iron ore processing automated control, *Metallurgical and Mining Industry*, No5, p.p.8-11: http://www.metaljournal.com.ua/assets/Journal/2-Morkun-Tr.pdf